MANAGEMENT OF EARTHWORM POPULATIONS IN CONIFEROUS FORESTS

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УПРАВЛЕНИЕ ПОПУЛЯЦИЯМИ ДОЖДЕВЫХ ЧЕРВЕЙ В ХВОЙНЫХ ЛЕСАХ

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Introduction

The importance of earthworms in litter breakdown and mull formation has been well documented. Since earthworms exert positive influence on several soil properties connected with fertility and productivity, the possibility of soil amelioration using introduced earthworm populations has evolved. Transplantation of earthworms is already becoming a large-scale practice in New Zealand pastures /12/. Promising results have also been reported in reclaimed polders in the Netherlands /3/.

The occurrence of earthworms in coniferous forest is strongly limited by low pH /10,8/ and unpalatability of coniferous litter /7,2/. The dominant

species is the acid-tolerant Dendrobaena octaedra, accompanied by the ubiquitous Lumbricus rubellus at moister sites /6,9,1/. Deep-burrowing species are usually lacking.

Management of earthworm populations in coniferous forests should therefore include either manipulation of pH, saving of a certain amount of hardwood among the conifers, or both. In /4/ it was recorded a considerable increase of the local population of L.rubellus as well as establishment of an introduced population of Aporrectodea caliginosa after these measures.

Relations between Environmental Factors and Occurrence of Earthworms

During the years 1983 and 1984 we have studied the occurrence of earthworms in relation to some environmental factors in Ruovesi, southern Finland. Earthworms were sampled qualitatively with spade and hand-sorting from 37 forest sites. Forest type, age of the stand, relative proportion of deciduous trees, previous practices (fertilization, prescribed burning), distance from arable land, soil texture and pH were recorded or measured. The results were treated with a LOGIT regression analysis, using the presence or absence of each species as the dependent variable.

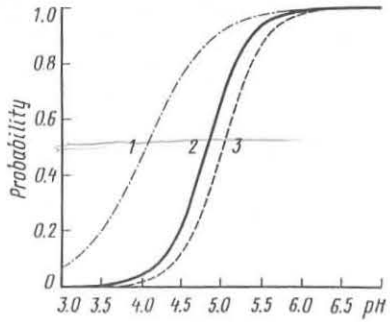
Soil acidity that varied between pH 3.8 and 5.8 was clearly the most important single factor to explain the occurrence of earthworms. The correlation with pH was significant even for D.octaedra, though it was recorded even at the lowest pH. For L.rubellus the probability of occurrence reached 50% level at pH 4.8, and for A.caliginosa at pH 5.0 (Fig.). pH alone explained 21% of the total variation for D.octaedra, 37% for L.rubellus, and 36.5% for A.caliginosa. No other parameter alone showed significant correlation with the presence of any species, but together with pH, bonity category and percentage of deciduous trees contributed to explain the total variation.

A.caliginosa has long been considered to be an acid-intolerant species. In regard to L.rubellus, our observations are in contradiction to some previous records. In /10/ it is regarded it as ubiquitous, and studies of /8/ and /11/ did not reveal correlation with pH for this species. On the other hand, several parameters are interconnected with pH, which may obscure causal relationships. Also it should be noted that presence or absence only was recorded in our study, and actual density may show different relation to acidity than does mere occurrence.

Establishment of Inoculated Populations

Inoculation experiments have been carried out in five forest sites in southern Finland representing different stand characteristics and different treatments. Development of populations have been monitored at varying intervals either qualitatively (digging) or by taking sets of 25x25 cm soil blocks, from which earthworms were extracted with a modified wet funnel technique /5/.

1) 3x3 m test plots in an old spruce stand were either supplied with deciduous litter, treated with lime, or both. Each plot was inoculated with 100 adult A.caliginosa in May 1973. Both treatments increased the existing populations of L.rubellus, and enabled establishment of the introduced populations of A.caliginosa (see /4/ for more details).



Probability of occurrence of three most common earthworm species in forest soil in relation to soil pH
1 - Allolobophora caliginosa; 2 - Lumbricus rubellus; 3 - Dendrobaena octaedra

By autumn 1978 both species started to diminish in plots treated with litter only, because no litter was added since October 1974. The effect of liming proved to be long-lasting; a strong population of A.caliginosa was still noted in August 1981. Six years after liming the pH of humus ranged between 6.1 and 6.5, while it was 4.0 to 4.1 in the control.

2) A total of 4000 A.caliginosa were introduced in August 1981 at 10 points in an alder (Alnus glutinosa) plantation, originally a spruce stand. Prior to the experiment, absence of the species was confirmed by intensive search. Presence of the population was recorded qualitatively two years later. The soil pH was about 4.8.

3) Ca. 200 A.caliginosa were introduced in May 1973 in a clear-cut area, originally a spruce stand, cut in winter1967-1968,reforested with pine,and treated with herbicide in 1979. A semiquantitative sample taken in September 1981 from the same site revealed 7 A.caliginosa, 6 L.rubellus and 51 D.octaedra per square metre.

4) Two 10x10 m plots, established in a spruce stand and fertilized with ashes in May, 1979, were inoculated in May 1982 with 1000 A.caliginosa or 500 A.caliginosa + 500 L.rubellus, respectively. In October, 1984, ca. 3 A.caliginosa m^{-1} was estimated in the former plot, and 3 A.caliginosa + 12 L.rubellus in the latter, in addition to a strong local population of D.octaedra. The pH of soil was between 4.7 and 5.2 at the moment of sampling.

5) 1000 A.caliginosa and 1000 L.rubellus were introduced in September, 1982 in several points in a young mixed stand of pine, birch and some alder, aged ten years. The pH of humus ranged between 4.3 and 4.8. A sparse population of both species (3 to 4 per square metre) was recorded two years later.

Discussion

Although our results are still partly tentative because of short duration of the more recent experiments, they offer strong support to the hypothesis that earthworm populations in coniferous forests can be managed with such simple practices as manipulation of pH or allowing growth of some hardwood. The latter measure is more appropriate for increasing the existing population of L.rubellus, which is less sensitive to acidity and more dependent on leaf litter for nutrition. On the other hand, although this species effectively removes litter from soil surface, as a surface-dweller it is not expected to essentially affect the soil structure.

The average pH of coniferous forest humus in Finland is slightly above 4. In /8/ a critical pH for abundant occurrence of A.caliginosa was reported to be 4.2,although sparse populations can be found at lower pH. This means that just a small decrease of acidity, which could be easily caused by a shift in the quality of litter, might enable the presence of A.caliginosa. The problem is that this species does not normally exist in coniferous forests, and trying to inoculate a population into a large area may encounter serious technical and economical difficulties. It also remains to be investigated, how far and how rapidly earthworms would affect the properties and productivity of forest.

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D i s c u s s i o n

Bieri M.: Have you also made a sample transect from south to north to investigate the effect of the winter length onto the occurrence of earthworm species?

Huhta V.: I have not collected in transects, but may I forward the question to Dr.Terhivuo?

Terhivuo J.: A sample transect has been made in 1970-1974. For further data and discussion see Terhivuo J., Valovirta I. Habitat spectra of the Lumbricidae (Oligochaeta) in Finland // Annales Zoologici Fennici. 1978. Vol.15. P. 202-209.

Dunger W.: Have you tried to introduce other species than A.caliginosa?

Huhta V.: Lumbricus rubellus was included in the experiments 4 and 5. Together with L.rubellus some L.terrestris probably came accidentally.

Paoletti M.G.: Did you follow the influence of earthworms on the litter layer and other soil properties?

Huhta V.: pH and nutrient contents were measured after six years in Experiment I. It came clearly out that earthworms had incorporated lime (applied superficially) into deeper horizons, simultaneously increasing the pH (see Huhta, 1979). We have started experiments in laboratory, where it can be seen that L.rubellus effectively removes leaf litter from soil surface.Our study will continue.

The question: Why did you chose L.rubellus for your experiments, and not L.terrestris?

How did you make the introductions?

Huhta V.: I wanted to start with species that occur most abundantly in our soils and are commercially available at reasonable cost. In experiments I and 2 ca. 10 specimens at a time were released in small pits made by hand. In the other experiments the worms were transported in buckets together with ripe compost; this was divided into roughly equal portions and inserted into larger pits made with shovel, each pit receiving from 50 to 200 worms with substrate.

Makeschin F.: What is your opinion about the meaning of autochthonous predators during inoculation of earthworms?

Huhta W.: It may be great, but I have no idea of its magnitude. However,probably at least some specimens avoid predation and give rise to a population. There is always a time lack of several years before populations are properly established and start spreading into the surroundings.